CLAIMS

What is claimed is:

1. A method for nanomachining a precise structure, comprising:

irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in said wafer;

depositing a layer of resist material over said irradiated surface of said wafer;

selectively removing portions of said layer of resist material to generate an etching pattern on irradiated surface of said wafer; and

etching said wafer according to said etching pattern.

2. A method as recited in claim 1, wherein said charged particle beam is directed to said surface of said wafer with a predetermined collimation at a desired direction.

3. A method as recited in claim 1, wherein said etched wafer comprises a final nanomachined structure.

4. A method as recited in claim 1, wherein said etched wafer comprises a negative of a final nanomachined structure.

5. A method as recited in claim 4, wherein said final nanomachined structure is formed by electroforming using said negative.

6. A method as recited in claim 5, wherein said electroforming comprises electroplating.

7. A method as recited in claim 1, wherein said wafer comprises a semiconductor material.

8. A method as recited in claim 1, wherein said wafer comprises an insulator material.

9. A method as recited in claim 1, wherein said charged particle beam is produced by removing some or all electrons from neutral atoms by an accelerator or comprises alpha particles emitted from a radioactive source.

10. A method as recited in claim 1, wherein said irradiating of said wafer comprises placing said wafer in said particle beam in a desired direction with respect to the wafer surface.

11. A method as recited in claim 10, wherein said desired direction is perpendicular to the wafer surface.

12. A method as recited in claim 10, wherein said desired direction has an angle of less than ninety degrees with respect to the plane of the wafer surface.

13. A method as recited in claim 1, wherein said particle tracks are substantially parallel to each other.

14. A method as recited in claim 1, wherein said particle tracks are oriented to intercept at a substantially small point if extended.

15. A method as recited in claim 1, wherein said step of depositing a layer of resist material over said irradiated surface of said wafer comprises deposition of a single or multilevel resist layers using spinning or vacuum coating.

16. A method as recited in claim 1, wherein said layer of resist material is suitable for producing said etching pattern and is stable during said etching step.

17. A method as recited in claim 1, wherein said step of selectively removing portions of said layer of resist material to generate an etching pattern on irradiated surface of said wafer comprises writing a pattern on said layer of resist material using an electron beam writing machine and subsequent processing to produce the desired pattern.

18. A method as recited in claim 1, wherein said layer of resist material comprises a single layer of organic resist material.

19. A method as recited in claim 1, wherein said layer of resist material comprises electron beam resist.

20. A method as recited in claim 1, wherein said layer of resist material comprises a multilevel resist structure established for improving the aspect ratio of electron beam lithography.

21. A method as recited in claim 17, wherein said subsequent processing comprises dissolution of selective portions of said layer of resist material using a solvent.

22. A method as recited in claim 17:

wherein said layer of resist material comprises sublayers of dissimilar materials; and

wherein said subsequent processing comprises dissolution of selective portions of said layer of resist material using a solvent and plasma based etching.

23. A method as recited in claim 1:

wherein said etching of said wafer comprises immersing said wafer in an etching solution;

wherein said etching pattern is partially or completely transferred to the wafer with aspect ratio substantially greater than that in said etching pattern.

24. A method as recited in claim 23, wherein said etched wafer comprises a final nanomachined structure.

25. A method as recited in claim 23, wherein said etched wafer comprises a negative of a final nanomachined structure.

26. A method as recited in claim 25, wherein said final nanomachined structure is formed by electroforming using said negative.

27. A method as recited in claim 26, wherein said electroforming comprises electroplating.

28. A particle-track-guided-etching method for nanomachining a precise structure with a high aspect ratio, comprising:

irradiating the surface of a wafer with a charged particle beam of suitable energy to form particle tracks in said wafer with a desired depth and alignment;

depositing a layer of pattern forming resist material on the wafer surface irradiated by said particle beam;

generating a precise pattern on the pattern forming layer; and

etching the areas of said wafer that are not covered by the precise pattern.

29. A method as recited in claim 28, wherein said charged particle beam is

directed to said surface of said wafer with a predetermined collimation at a desired direction.

30. A method as recited in claim 28, wherein said etched wafer comprises a final nanomachined structure.

31. A method as recited in claim 28, wherein said etched wafer comprises a negative of a final nanomachined structure.

32. A method as recited in claim 31, wherein said final nanomachined structure is formed by electroforming using said negative.

33. A method as recited in claim 32, wherein said electroforming comprises electroplating.

34. A method as recited in claim 28, wherein said wafer comprises a semiconductor material.

35. A method as recited in claim 28, wherein said wafer comprises an insulator material.

36. A method as recited in claim 28, wherein said charged particle beam is produced by removing some or all electrons from neutral atoms by an accelerator or consists of alpha particles emitted from a radioactive source.

37. A method as recited in claim 28, wherein said irradiating of said wafer comprises placing said wafer in said particle beam in a desired direction with respect to the wafer surface.

38. A method as recited in claim 37, wherein said desired direction is perpendicular to the wafer surface.

39. A method as recited in claim 37, wherein said desired direction has an angle of less than ninety degrees with respect to the plane of the wafer surface.

40. A method as recited in claim 28, wherein said particle tracks are substantially parallel to each other.

41. A method as recited in claim 28, wherein said particle tracks are oriented to intercept at a substantially small point if extended.

42. A method as recited in claim 28, wherein said step of depositing a layer of resist material over said irradiated surface of said wafer comprises deposition of a

single or multilevel resist layers using spinning or vacuum coating.

43. A method as recited in claim 28, wherein said layer of resist material is suitable for producing said etching pattern and is stable during said etching step.

44. A method as recited in claim 28, wherein said step of selectively removing portions of said layer of resist material to generate an etching pattern on irradiated surface of said wafer comprises writing a pattern on said layer of resist material using an electron beam writing machine and subsequent processing to produce the desired pattern.

45. A method as recited in claim 28, wherein said layer of resist material comprises a single layer of organic resist material.

46. A method as recited in claim 28, wherein said layer of resist material comprises electron beam resist.

47. A method as recited in claim 28, wherein said layer of resist material comprises a multilevel resist structure established for improving the aspect ratio of electron beam lithography.

48. A method as recited in claim 44, wherein said subsequent processing comprises dissolution of selective portions of said layer of resist material using a solvent.

49. A method as recited in claim 44:

wherein said layer of resist material comprises sublayers of dissimilar materials; and

wherein said subsequent processing comprises dissolution of selective portions of said layer of resist material using a solvent and plasma based etching.

50. A method as recited in claim 28:

wherein said etching of said wafer comprises immersing said wafer in an etching solution;

wherein said etching pattern is partially or completely transferred to the wafer with aspect ratio substantially greater than that in said etching pattern.

51. A method as recited in claim 50, wherein said etched wafer comprises a final nanomachined structure.

52. A method as recited in claim 50, wherein said etched wafer comprises a negative of a final nanomachined structure.

53. A method as recited in claim 52, wherein said final nanomachined structure is formed by electroforming using said negative.

54. A method as recited in claim 53, wherein said electroforming comprises electroplating.

55. A particle-track-guided-etching method for nanomachining a precise structure with a high aspect ratio, comprising:

irradiating a wafer with a charged particle beam of suitable energy and predetermined collimation at a desired direction with respect to said wafer surface to form particle tracks in said wafer with a desired depth and alignment;

depositing a layer of pattern forming resist material on the wafer surface irradiated by the particle beam;

generating a precise pattern on the pattern forming layer; and

etching the areas of wafer that are not covered by the precise pattern.

56. A method as recited in claim 55, wherein said etched wafer comprises a final nanomachined structure.

57. A method as recited in claim 55, wherein said etched wafer comprises a negative of a final nanomachined structure.

58. A method as recited in claim 57, wherein said final nanomachined structure is formed by electroforming using said negative.

59. A method as recited in claim 58, wherein said electroforming comprises electroplating.

60. A method as recited in claim 55, wherein said wafer comprises a semiconductor material.

61. A method as recited in claim 55, wherein said wafer comprises an insulator material.

62. A method as recited in claim 55, wherein said charged particle beam is produced by removing some or all electrons from neutral atoms by an accelerator or consists of alpha particles emitted from a radioactive source.

63. A method as recited in claim 55, wherein said irradiating of said wafer comprises placing said wafer in said particle beam in a desired direction with respect to the wafer surface.

64. A method as recited in claim 63, wherein said desired direction is perpendicular to the wafer surface.

65. A method as recited in claim 63, wherein said desired direction has an angle of less than ninety degrees with respect to the plane of the wafer surface.

66. A method as recited in claim 55, wherein said particle tracks are substantially parallel to each other.

67. A method as recited in claim 55, wherein said particle tracks are oriented to intercept at a substantially small point if extended.

68. A method as recited in claim 55, wherein said step of depositing a layer of resist material over said irradiated surface of said wafer comprises deposition of a single or multilevel resist layers using spinning or vacuum coating.

69. A method as recited in claim 55, wherein said layer of resist material is suitable for producing said etching pattern and is stable during said etching step.

70. A method as recited in claim 55, wherein said step of selectively removing portions of said layer of resist material to generate an etching pattern on irradiated surface of said wafer comprises writing a pattern on said layer of resist material using an electron beam writing machine and subsequent processing to produce the desired pattern.

71. A method as recited in claim 55, wherein said layer of resist material comprises a single layer of organic resist material.

72. A method as recited in claim 55, wherein said layer of resist material comprises electron beam resist.

73. A method as recited in claim 55, wherein said layer of resist material comprises a multilevel resist structure established for improving the aspect ratio of electron beam lithography.

74. A method as recited in claim 70, wherein said subsequent processing comprises dissolution of selective portions of said layer of resist material using a solvent.

75. A method as recited in claim 70:

wherein said layer of resist material comprises sublayers of dissimilar materials; and

wherein said subsequent processing comprises dissolution of selective portions of said layer of resist material using a solvent and plasma based etching.

76. A method as recited in claim 55:

wherein said etching of said wafer comprises immersing said wafer in an etching solution;

wherein said etching pattern is partially or completely transferred to the wafer with aspect ratio substantially greater than that in said etching pattern.

77. A method as recited in claim 76, wherein said etched wafer comprises a final nanomachined structure.

78. A method as recited in claim 76, wherein said etched wafer comprises a negative of a final nanomachined structure.

79. A method as recited in claim 78, wherein said final nanomachined structure is formed by electroforming using said negative.

80. A method as recited in claim 79, wherein said electroforming comprises electroplating.